7. Duct Efficiency Improvements Including HERS Required Field Verification and Diagnostic Testing for Duct Sealing

7.1 Duct Efficiency Improvements

The Commission has approved algorithms and procedures for determining HVAC air distribution system (duct) efficiency for non-residential single-zone packaged equipment units serving 5000 ft^2 or less via ductwork that is installed in buffer spaces or unconditioned areas.. Details of the energy efficiency calculations are presented in Appendix NG.

Section 144(k) of the Standards sets a prescriptive requirement for HERS rater diagnostically tested and field verified duct sealing for duct systems that meet the following criteria (note this is a subset of the duct systems for which the ACM calculations shall be applied):

1. Connected to constant volume, single zone, air conditioners, heat pumps or furnaces, and
2. Serving less than 5,000 square feet of floor area; and
3. Having more than 25% duct surface area located in one or more of the following spaces:
   A. Outdoors, or
   B. In a space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling, or
   C. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or
   D. In an unconditioned crawlspace; or
   E. In other unconditioned spaces.

This requirement applies to new buildings and to additions. Section 149(b)1.D sets a requirement for HERS rater diagnostically tested and field verified duct sealing for alterations of existing buildings where a new duct system is being installed or an existing duct system is being replaced for duct systems meeting the same criteria. Section 149(b)1.E sets a requirement for HERS rater diagnostically tested and field verified duct sealing for existing duct systems in duct systems meeting the same criteria when the space conditioning system is being installed or replaced, including replacement or installation of an air handler, cooling or heating coil, or furnace heat exchanger. Section 124 sets a mandatory minimum duct insulation requirement of R-8 for duct systems meeting the same criteria.

There are two calculation procedures to determine HVAC system air distribution (duct) efficiency using either: 1) default input assumptions, or 2) values based on HERS rater diagnostic testing and field verification. Duct efficiencies for heating and cooling shall be calculated separately. The ACM shall require the user to choose values for the following parameters to calculate duct efficiencies: duct insulation level and duct leakage level.

For duct systems in new buildings and additions meeting the section 144(k) criteria, the ACM shall assume R-8 duct insulation and duct leakage of 8% of fan flow for the standard design. For the proposed design the same R-8 duct insulation value shall be used since that is a mandatory requirement. When the documentation author specifies duct sealing, which requires HERS rater field verification and diagnostic testing, the proposed design for duct leakage shall be the same as the standard design. If the documentation does not specify duct sealing, the proposed design shall be the default value for duct leakage of 36% of fan flow.

For new or replacement duct systems in existing buildings meeting the Section 144(k) criteria, the ACM shall assume R-8 duct insulation for the new or replaced ducts, and if the new or replaced ducts make up only a portion of the duct system, the ACM shall assume R-4.2 duct insulation for the existing ducts. The proposed design shall use the same R-8 duct insulation for the new or replaced ducts and the actual installed duct insulation for the existing ducts. The ACM shall assume duct leakage of 17% of fan flow for the standard design for new or replacement duct systems, including existing portions of the duct system. When the documentation author specifies duct sealing meeting the requirements of Section 149(b)1.D, including HERS rater field verification and diagnostic testing, the proposed design for duct leakage shall be the same as the standard design. If the documentation does not specify duct sealing, the proposed design shall be the default value of duct leakage of 36% of fan flow.

For existing duct systems in existing buildings meeting the Section 144(k) criteria, the ACM shall assume R-4.2 duct insulation and duct leakage of 17% of fan flow. The proposed design shall assume either R-4.2 duct insulation or the actual installed duct insulation. The ACM shall assume duct leakage of 17% of fan flow for the standard design for new or replacement duct systems, including existing portions of the duct system. When the documentation author specifies duct sealing meeting the requirements of Section 149(b)1.E, including HERS rater field verification and diagnostic testing, the proposed design for duct leakage shall be the same as the standard design. If the documentation does not specify duct sealing, the proposed design shall be the default value for duct leakage of 36% of fan flow.

For duct systems for single-zone individual packaged equipment serving 5000 ft^2 or less via ductwork that is installed in spaces that are not directly conditioned, which do not meet the Section 144(k) criteria, the ACM shall assume R4.2 duct insulation for the standard design. The proposed design shall assume either R4.2 or the actual installed duct insulation. The ACM shall assume the default value for duct leakage of 36% of fan flow. When the documentation author specifies duct sealing, including HERS rater field verification and diagnostic testing, the proposed design shall assume duct leakage of 8% of fan flow for duct systems in new buildings and additions meeting the duct leakage requirements of Section 144(k), and duct leakage of 17% for duct systems in existing buildings meeting the duct leakage requirements of Sections 149(b)1.D or 149(b)1.E.

The ACM shall automatically determine whether duct systems are for single-zone individual packaged equipment serving 5000 ft^2 or less via ductwork that is installed in spaces that are not directly conditioned, and whether such duct systems meet the criteria of Section 144(k). This determination shall be made based on inputs required for analyzing other HVAC features or inputs created especially to make this determination. The ACM shall automatically use the following values from the description of the proposed design when calculating the distribution system (duct) efficiency:

- Number of stories
- Building Conditioned Floor Area
- Building Volume
- Outdoor summer and winter design temperatures for each climate zone

When more than one HVAC system serves the building, the HVAC distribution efficiency is determined for each system and is applied to the energy consumption of each system.

Duct sealing shall be listed as *HERS Verification Required* features on the *Performance Certificate of Compliance* (PERF-1) and the *Mechanical Compliance Summary* (MECH-1), and *Mechanical Distribution Summary* (MECH-5). Field verification and diagnostic testing constitutes “eligibility and installation criteria” for duct sealing. Field verification and diagnostic testing of duct sealing shall be described in the *Compliance Supplement*.

7.2 California Home Energy Rating Systems

Compliance credit for duct sealing for HVAC systems covered by sections 144(k), 149(b)1.D and 149(b)1.E of the Standards requires field verification and diagnostic testing of as-constructed duct systems by a certified HERS

rater, using the testing procedures in Appendix NG. The Commission approves HERS providers, subject to the Commission's HERS Program regulations, which appear in the California Code of Regulations, Title 20, Chapter 4, Article 8, Sections 1670-1676). Approved HERS providers are authorized to certify HERS raters and maintain quality control over field verification and diagnostic testing. When User's Manual and Help System indicates field verification and diagnostic testing of specific energy efficiency improvements as a condition for those improvements to qualify for Title 24 compliance credit, an approved HERS provider and certified HERS rater shall be used to conduct the field verification and diagnostic testing. HERS providers and raters shall be considered special inspectors by building departments, and shall demonstrate competence, to the satisfaction of the building official, for the field verifications and diagnostic testing. The HERS provider and rater shall be independent entities from the builder or subcontractor installer of the energy efficiency improvements being tested and verified, and shall have no financial interest in the installation of the improvements. Third-party quality control programs approved by the Commission may serve the function of HERS raters for field verification and diagnostic testing purposes as specified in Section 7.6.

7.3 Summary of Documentation and Communication

The documentation and communication process for duct sealing field verification and diagnostic testing is summarized below. The subsequent sections of this chapter contain additional information.

- The documentation author and the principal mechanical designer shall complete the compliance documents, including the MECH-1 for the building.
- The documentation author or the principal mechanical designer shall provide a signed Certificate of Compliance (MECH-1) to the builder, which indicates that duct sealing with HERS rater diagnostic testing and field verification is required for compliance. The builder or principal mechanical designer shall make arrangements for the services of a certified HERS rater prior to installation of the duct system, so that once the installation is complete the HERS rater has ample time to complete the field verification and diagnostic testing without delaying final approval of occupancy by the building department.
- The builder's subcontractor installs the duct systems which require field verification and diagnostic testing, as specified by Section 7.1. The builder or builder's installer shall complete diagnostic testing and the procedures specified in Section 7.5. When the installation is complete, the builder or the builder's subcontractor shall complete the installer's portion of the MECH-5, Mechanical Distribution Summary, and keep it at the building site for review by the building department. The builder also shall provide a copy of the completed installer's portion of the MECH-5 to the HERS rater.
- The HERS rater shall complete the field verification and diagnostic testing as specified in Section 7.1, completes the HERS rater's portion of the MECH-5, and provides a signed MECH-5 to the HERS provider, builder and building department. The building department shall not approve a building with individual single zone package space conditioning equipment unit for occupancy until the building department has received a MECH-5 that has been signed by the certified HERS rater.

7.4 Installation Certification

When compliance includes duct sealing, builder employees or subcontractors shall complete diagnostic testing, and certify on the installer's portion of the (MECH-5) the diagnostic test results and that the work meets the requirements for compliance credit.

Installer certifications are required for each and every building, and for every single zone package space conditioning equipment unit in the building that requires duct sealing with HERS rater field verification and diagnostic testing, if more than one such space conditioning equipment unit is installed in the building.

7.5 Field Verification and Diagnostic Testing Procedures

At the builder's option, HERS field verification and diagnostic testing shall be completed either for each single zone package space conditioning equipment unit in the building or for a sample of all of the units that are installed in the building. Field verification and diagnostic testing for compliance credit for duct sealing shall use the diagnostic duct leakage from fan pressurization of ducts in ACM Appendix NG.

The builder shall provide the HERS provider a copy of the MECH-5 containing the installer certifications required in Section 7.5. Prior to completing field verification and diagnostic testing, the HERS rater shall first verify that the installation certifications have been completed.

If the builder chooses the sampling option, the procedures described in this section shall be followed. Sampling procedures described in this section shall be included in the *Compliance Supplement*.

7.5.1 Initial Field Verification and Testing

The HERS rater shall diagnostically test and field verify the first individual single zone package space conditioning equipment unit of each building. This initial testing allows the builder to identify and correct any potential duct installation and sealing flaws or practices before other units are installed. If field verification and diagnostic testing determine that the requirements for compliance are met, the HERS rater shall provide a signed and dated MECH-5 to the builder, the HERS provider, and the building department.

7.5.2 Sample Field Verification and Testing

After the initial testing is completed, the builder shall identify a group of up to seven individual single zone package space conditioning equipment units in the building from which a sample will be selected for testing, and notify the HERS provider.

The builder may remove units from the group by notifying the HERS provider. Removed units which are installed shall either be field verified and diagnostically tested individually or shall be included in a subsequent group for sampling.

The HERS rater shall select a minimum of one unit out of the group for diagnostic testing and field verification. When several units are ready for testing at the same time, the HERS rater shall randomly select the unit to be tested. The HERS rater shall diagnostically test and field verify the unit selected by the HERS rater.

If field verification and diagnostic testing determines that the requirements for compliance are met, the HERS rater shall provide a signed and dated MECH-5 to the builder, the HERS provider, and the building department. The MECH-5 shall report the successful diagnostic testing results and conclusions regarding compliance for the tested unit. The HERS rater shall also provide a signed and dated MECH-5 to the builder, the HERS provider, and the building department for up to six additional units in the group. The MECH-5 shall not be provided for units that have not yet been installed and sealed.

Whenever the builder changes subcontractors who are responsible for installation of the space conditioning equipment units, the builder shall notify the HERS rater of any subcontractors who have changed, and terminate sampling for the identified group. All units requiring HERS rater field verification and diagnostic testing for compliance that were installed by previous subcontractors or were subject to field verification and diagnostic testing under the supervision of a previous HERS provider, for which the builder does not have a completed MECH-1, shall either be individually tested or included in a separate group for sampling. Individual single zone package space conditioning equipment units that are subject to the requirements of Section 144(k) with installations completed by new subcontractors shall either be individually tested or shall be included in a new sampling group following a new *Initial Field Verification and Testing*.

The HERS rater shall not notify the builder when sample testing will occur prior to the completion of the work that is to be tested. After the HERS rater notifies the builder when testing will occur, the builder shall not do additional work on the features being tested.

7.5.3 Re-sampling, Full Testing and Corrective Action

When a failure is encountered during sample testing, the HERS rater shall conduct re-sampling to assess whether that failure is unique or the rest of the units are likely to have similar failings. The HERS rater shall select for re-sampling one of the up to six untested units in the group.

If testing in the units in the re-sample confirms that the requirements for compliance credit are met, then the unit with the failure shall not be considered an indication of failure in the other units in the group. The HERS rater shall provide a signed and dated MECH-5 to the builder, the HERS provider, and the building department for up to six additional units in the group, including the unit in the re-sample. The builder shall take corrective action for the unit with the failure, and then the HERS rater shall retest that unit to verify compliance and issue a signed and dated to the builder.

If field verification and testing in the re-sample results in a second failure, the builder shall take corrective action in all space conditioning units in the group that have not been tested. In cases where corrective action would require destruction of building components, the builder may choose to reanalyze compliance and choose different measures that will achieve compliance. In this case a new Certificate of Compliance (MEC-1) shall be completed and submitted to the HERS provider, HERS rater and building department. The HERS rater shall conduct field verification and diagnostic testing for each of these space conditioning units to verify that problems have been corrected and that the requirements for compliance have been met, and shall report to the HERS provider, the builder, and the building department.

The HERS provider shall file a report with the building department explaining all action taken (including field verification, testing, and corrective action,) to bring into compliance units for which full testing has been required. If corrective action requires work not specifically exempted by Section 112 of the CMC or Section 106 of the CBC, the builder shall obtain a permit from the building department prior to commencement of any of the work.

If additional units in the group are completed during the time required to correct, field verify and test the previously installed units in the group, the rater shall individually field verify and diagnostically test those additional units to confirm that the requirements for compliance credit are met.

Corrections shall not be made to a sampled or re-sampled unit to avoid a failure. If corrections are made to a sampled or re-sampled unit to avoid a failure, corrections, field verification and testing shall be performed on 100% of the individual single zone package space conditioning equipment units in the group.

7.6 Third Party Quality Control Programs

The Commission may approve third-party quality control programs that serve the function of HERS raters for diagnostic testing and field verification purposes. The third-party quality control program shall provide training to installers regarding compliance requirements for measures for which diagnostic testing and field verification is required. The third-party quality control program shall collect data from participating installers for each installation completed for compliance credit, complete data checking analysis to evaluate the validity and accuracy of the data to independently determine whether compliance has been achieved, provide direction to the installer to retest and correct problems when data checking determines that compliance has not been achieved, require resubmission of data when retesting and correction is directed, and maintain a database of all data submitted by installers in a format that is acceptable to the Commission and available to the Commission upon request. The data that is collected by the third-party quality control program shall be more detailed than the data required for showing compliance with the Standards, shall provide an independent check on the validity and accuracy of the installer's claim that compliance has been achieved, and shall not be alterable by the installer to indicate that compliance has been achieved when in fact compliance has not been achieved.

The third-party quality control program shall also obtain the services of a HERS rater to conduct independent field verifications, completing all of the responsibilities of a HERS rater as specified in this chapter with the exception that sampling shall be completed for a group of up to thirty space conditioning units with a minimum sample of one out of every 30 sequentially completed units from the group. The HERS rater shall be an independent entity

from the third-party quality control program. Re-sampling, full testing and corrective action shall be completed as specified in Section 7.5.3 with the exception that re-sampling shall be completed for a minimum of one out of every 30 units from the group.

The third-party quality control program shall meet all of the requirements of a HERS rater specified in the Commission's HERS Program regulations (California Code of Regulations, Title 20, Division 2, Chapter 4, Article 8, Sections 1670 -1675), including the requirement to be an independent entity from the builder and the HERS rater that provides independent field verifications, subcontractor installer as specified by Section 1673(i). A third-party quality control program may have business relationships with installers participating in the program to advocate or promote the program and an installer's participation in the program, and to advocate or promote products that the third-party quality control program sells to installers as part of the program.

Prior to approval by the Commission, the third-party quality control program shall provide a detailed explanation to the Commission of 1) the data that is to be collected from the installers, 2) the data checking process that will be used to evaluate the validity and accuracy of the data, 3) the justification for why this data checking process will provide strong assurance that the installation actually complies, and 4) the format for the database that will be maintained and provided to the Commission upon request. The third-party quality control program may apply for a confidential designation of this information as specified in the Commission's Administrative Regulations (California Code of Regulations, Title 20, Division 2, Chapter 7, Article 2, Section 2505). The third-party quality control program shall also provide a detailed explanation of the training that will be provided to installers, and the procedures that it will follow to complete independent field verifications.

The third-party quality control program shall be considered for approval as part of the rating system of a HERS provider, which is certified as specified in the Commission's HERS Program regulations, Section 1674. A third-party quality control program can be added to the rating system through the re-certification of a certified HERS provider as specified by Section 1674(d).

7.7 Sampling for Additions or Alterations

When compliance for an addition or alteration requires diagnostic testing and field verification, the building permit applicant may choose for the testing and field verification to be completed for the permitted space alone or as part of a sample of space conditioning units for which the same installing company has completed work that requires testing and field verification for compliance. The building permit applicant shall complete the applicable portions of a MECH-1. The HERS provider shall define the group for sampling purposes as all units where the building permit applicant has chosen to have testing and field verification completed as part of a sample for the same installing company. The group shall be no larger than seven. The installing company may request a smaller group for sampling. Whenever the HERS rater for an installing company is changed, a new group shall be established. Initial field verification and testing shall be completed for the first unit in each group. Re-sampling, full testing and corrective action shall be completed if necessary as specified by Section 7.5.3.

Field verification and diagnostic testing may be completed by an approved third-party quality control program as specified in Section 7.6. The group for sampling purposes shall be no larger than 30 when a third-party quality control program is used. The third-party quality control program may define the group instead of the provider. When a third-party quality control program is used, the MECH-5 shall document that data checking has indicated that the unit complies. The building official may approve compliance based on the MECH-5 where data checking has indicated that the unit complies, on the condition that if sampling indicates that re-sampling, full testing, and corrective action is necessary, such work shall be completed.

7.8 Summary of Responsibilities

This section summarizes responsibilities described previously in this chapter and organizes them by the responsible party.

7.8.1 Builder

The builder shall make arrangements for the services of a certified HERS rater prior to installation of the duct systems, so that once the installation is complete the HERS rater has ample time to complete the field verification and diagnostic testing without delaying final approval of occupancy by the building department.

Builder employees or subcontractors responsible for completing diagnostic testing, as specified in Section 7.5 shall certify the diagnostic testing results and that the work meets the requirements for compliance credit on the installer's portion of the MECH-5.

If the builder chooses to have HERS rater field verification and diagnostic testing completed through sampling, the builder shall identify for the HERS provider the group of space conditioning units to be included in the sample. The builder shall provide the HERS provider a copy of the MECH-5 with the installer's portion signed by the builder employees or sub-contractors, certifying that diagnostic testing and installation meet the requirements for compliance credit.

The builder shall provide a MECH-5 signed and dated by the HERS rater to the building official in conjunction with requests for final inspection for each individual single zone package space conditioning equipment unit.

7.8.2 HERS Provider and Rater

The HERS provider shall maintain a list of the space conditioning units in the group from which sampling is drawn, the units selected for sampling, the units sampled and the results of the sampling, the units selected for re-sampling, the units that have been tested and verified as a result of re-sampling, the corrective action taken, and copies of all MECH-5 forms for a period of five years.

The HERS rater providing the diagnostic testing and verification shall sign and date a MECH-5 certifying that he/she has verified that the requirements for compliance credit have been met. A MECH-5 shall be provided for the tested space conditioning unit and each of up to six other units from the group for which compliance is verified based on the results of the sample. The HERS rater shall provide copies of the signed MECH-5 to the builder, the HERS provider, and the building department.

The HERS rater shall identify on the MECH-5 if the space conditioning unit has been tested or if it was an untested unit approved as part of sample testing. The HERS rater shall not sign a MECH-5 for a building with a space conditioning unit that does not have the installer's portion of the MECH-5 signed by the installer as required in Section 7.5.

If field verification and testing on a sampled space conditioning unit identifies a failure to meet the requirements for compliance credit, the HERS rater shall report to the HERS provider, the builder, and the building department that re-sampling will be required.

If re-sampling identifies another failure, the HERS rater shall report to the HERS provider, the builder, and the building department that corrective action and diagnostic testing and field verification will be required for all the untested space conditioning units in the group. This report shall identify each space conditioning unit that shall be fully tested and corrected.

The HERS provider shall also report to the builder once diagnostic testing and field verification has shown that the failures have been corrected for all of the space conditioning units.

When individual space conditioning unit testing and verification confirms that the requirements for compliance have been met, the HERS rater shall provide a signed and dated MECH-5 for each space conditioning unit in the group.

The HERS provider shall file a report with the building department explaining all action taken (including field verification, testing, and corrective actions) to bring into compliance space conditioning units for which full testing has been required.

7.8.3 Third-Party Quality Control Program

An approved third-party quality control program shall:

- Provide training to installers regarding compliance requirements for measures for which diagnostic testing and field verification is required,
- Collect data from participating installers for each installation completed for compliance credit,
- Complete data checking analysis to evaluate the validity and accuracy of the data to independently determine whether compliance has been achieved,
- Provide direction to the installer to retest and correct problems when data checking determines that compliance has not been achieved,
- Require resubmission of data when retesting and correction is directed, and
- Maintain a database of all data submitted in a format that is acceptable to the Commission and available to the Commission upon request.

The third-party quality control program shall obtain the services of an independent HERS rater to conduct independent field verifications, completing all of the responsibilities of a HERS rater as specified in this Chapter with the exception that sampling shall be completed for a group of up to 30 space conditioning units, and sampling and re-sampling shall be completed for a minimum of one out of every 30 sequentially completed units from the group.

7.8.4 Building Department

When the Certificate of Compliance (MECH-1) indicates duct sealing requiring HERS diagnostic testing and field verification for compliance, the building department shall verify that the Documentation Author has notified the HERS provider before accepting the MECH-1.

The building department at its discretion may require independent testing and field verification to be scheduled so that it can be completed in conjunction with the building department's required inspections, and/or observe the diagnostic testing and field verification performed by builder employees or subcontractors and the certified HERS rater in conjunction with the building department's required inspections to corroborate the results documented in installer certifications, and HERS rater field verifications on the MECH-5.

For space conditioning units that have used a compliance alternative that requires field verification and diagnostic testing, the building department shall not approve a building for occupancy until the building department has received a MECH-5 that has been signed and dated by the HERS rater.